This application is a Continuation of International Application PCT/FI02/00429 filed on 20.5.2002, which designated the U.S. and was published under PCT Article 21(2) in English.

CASTING RECEPTABLE AND CASTING METHOD

FIELD OF THE INVENTION

[0001] The invention relates to a casting receptable for processing melt, the casting receptable comprising a lid, a shell, the bottom part of which is substantially in the shape of a cut cone and downwards convergent, and a filling opening at the bottom of the casting receptable, and further a shutter plug that is movable in the vertical direction by means of an actuator and arranged to close and open the filling opening to allow melt to enter and correspondingly exit the casting receptable.

[0002] The invention further relates to a casting method that comprises the following steps: melting the metal to be cast in a melting furnace; using a closed casting receptable to transfer the melt from the melting furnace to the casting site, the bottom part of the casting receptable shell being a convergent substantially conical part in shape and the bottom of the casting receptable having a filling opening that is opened and closed by means of a shutter plug that is movable in the vertical direction; eliminating harmful gases inside the casting receptable prior to filling the casting receptable; immersing the casting receptable into the melt in the melting furnace to a predetermined depth and opening the filling opening by moving the shutter plug to allow the melt in the melting furnace to flow into the casting receptable; closing the filling opening by means of the shutter plug and transferring the casting receptable to the casting site; connecting the filling opening of the casting receptable to a feed channel of the casting item and opening the filling opening by means of the shutter plug to allow the melt inside the casting receptable to flow into the feed channel and onwards to a casting mould.

BACKGROUND OF THE INVENTION

[0003] Metal castings are made by a casting technique, in which the mould cavity of a mould is filled with melt metal. When solidifying, the melt metal forms a casting in the shape of the mould cavity. The metal is melted in a melting furnace, from which it is transferred in a casting receptable to the mould and poured into the feed channel of the mould. Alternatively, the melt is

taken to a casting machine and poured into a feed channel in the casting machine, from which a feed cylinder of the casting machine pushes the melt into the mould cavity. The currently used casting receptables are generally open at the top and filled by immersing the casting receptable into the melt heated in the furnace, whereby the melt metal can flow over the top edge of the casting receptable inside the casting receptable. A problem with this is that the surface of the melt usually has slag and oxides that, when the casting receptable is filled, flow into the casting receptable with the melt and on into the mould cavity during casting. These impurities cause casting defects in the casting that weaken the mechanical properties and appearance of the casting. It has also been detected that slag and oxide particles wear the feed equipment and casting mould of the casting machine.

[0004] When using casting receptables that are filled over the top edge, the melt in the furnace cannot be protected with protective slag, and the melt needs to be processed with melt cleaning materials before casting to remove oxides from the melt. A drawback of the melt cleaning process is that is slows down the casting process. Further, the materials used in the cleaning process are hazardous to the environment and the health of the workers.

[0005] US patent publication 4,121,651 discloses a closed casting receptable having at its bottom a filling opening that can be opened and closed. The casting receptable is filled by immersing it into the melt in a furnace, whereby the melt flows into the casting receptable through the opened filling opening. After this, the filling opening is closed by vertically moving a hollow shutter rod arranged through the casting receptable. Inside the hollow rod, there is an inner rod so that a circular channel remains between the rods for gas transmission. Further, at the outermost end of the inner rod arranged inside the hollow rod, there is a valve that settles against the bottom end of the hollow rod and when necessary closes the connection to the circular channel. The casting receptable disclosed in the US patent publication cannot successfully be used when the melt metal in the furnace is protected with protective slag, because if the casting receptable is immersed through the protective slag, the valve at the bottom end of the shutter rod pushes the protective slag from the surface of the melt with it. When the filling opening is then opened, the protective slag that is against the valve flows with the melt inside the casting receptable. Even when protective slag is not used, the valve pushes oxide films and other impurities on the surface of the melt with it, whereby the impuri-

ties enter the casting receptable when the filling opening is opened. Thus, the use of the casting receptable described in the publication cannot guarantee a good purity of the melt.

SUMMARY OF THE INVENTION

[0006] The object of the present invention is to achieve a novel and improved casting receptable and casting method that prevent the impurities on the surface of the melt from entering the casting receptable when it is filled.

[0007] The casting receptable of the invention is characterized in that the bottom end of the shutter plug is substantially a sharp cone in shape and that the bottom end of the shutter plug extends in its closed position a distance further than the substantially conical bottom part of the shell, thus forming a substantially sharp point at the bottom of the casting receptable, whereby the bottom part of the shell and the bottom end of the shutter plug form a substantially uniform conical outer surface.

[0008] Further, the casting method of the invention is characterized by using protective slag on the surface of the melt in the melting furnace to protect the melt from the influence of the gases outside the melting furnace; using a casting receptable in which the point of the shutter plug is shaped substantially sharp so that when closed, the shutter plug forms together with the substantially conical bottom part of the casting receptable shell a substantially uniform conical outer surface at the bottom of the casting receptable; pushing the casting receptable through the protective slag, whereby the substantially sharp-pointed bottom of the casting receptable moves the protective slag being in the movement of travel of the casting receptable and the possible impurities on the surface of the melt to the sides of the casting receptable, away from the bottom area of the casting receptable; connecting the casting receptable to a feed channel in such a manner that the gases in the air space of the casting site cannot enter the feed channel; and removing the gases that react harmfully with the melt from the feed channel and casting mould before the filling opening is opened.

[0009] The essential idea of the invention is that the top end of the casting receptable is closed and the bottom part of the shell is in the shape of a convergent cone. The bottom of the casting receptable has a filling opening that is opened and closed by means of a vertically movable shutter plug. The shutter plug goes through the casting receptable and is moved by means of suitable actuators. The bottom end of the shutter plug has a point that is sub-

stantially in the shape of a sharp cone. When the shutter plug is in its closed position, it forms together with the bottom part of the casting receptable shell a substantially uniform conical outer surface. This structure provides the advantage that when the casting receptable is immersed for filling into the melt in the melting furnace, the substantially sharp-pointed bottom part of the casting receptable pushes the impurities and protective slag on the surface of the melt smoothly out of the way to the sides of the casting receptable, which ensures that they do not at any stage enter the casting receptable during filling.

[0010] Further, the essential idea of the casting method of the invention is that during melting, protective slag is used on the surface of the furnace to protect the melt metal from oxidization. The metal to be cast is transferred from the melting furnace to the casting site in a closed casting receptable having a shell with a conical bottom part and a bottom end with a filling opening that can be opened and closed by means of a substantially sharp-pointed shutter plug. The casting receptable is filled by immersing the conical bottom end of the receptable to a predetermined depth of the metal melt in the melting furnace. When the casting receptable is pushed into the melt, the substantially sharp bottom end of the casting receptable penetrates the protective slag on the surface of the melt and pushes the protective slag aside, after which the shutter plug can be opened to allow the pure melt metal below the protective slag to flow inside the casting receptable. When the casting receptable contains a predetermined amount of melt metal, the filling opening is closed with the shutter plug. Further, vacuum or inert gas prevails inside the casting receptable so that the melt metal does not come into contact with the surrounding air. After filling, the casting receptable is transferred to the casting site in which the casting receptable is connected to a feed channel of the casting item in such a manner that the entry of the gases in the air space surrounding the casting site to the feed channel is prevented. Before casting, the gases that react harmfully with the melt metal are removed from the feed channel and casting mould. This can be done by creating negative pressure into the mould and/or flushing the mould with inert gas. Finally, the casting is done by opening the shutter plug of the casting receptable to allow the melt metal to flow from the casting receptable to the feed channel and on to the casting mould.

[0011] The method of the invention provides the advantage that melt metal is protected during the entire casting process from the harmful effects of air. Further, the invention enables the use of protective slag, whereby

the use of melt cleaning materials that are hazardous to the environment and to the health of the workers is avoided.

[0012] It should be noted that in this application, the term convergent/sharp cone used to describe the bottom part of the casting receptable and the bottom end of the shutter plug refers to a shape whose cross-profile area decreases downwards. A cone then also refers to a paraboloid, pyramid, hemisphere and other corresponding geometric shapes.

BRIEF DESCRIPTION OF THE FIGURES

[0013] The invention will be described in greater detail in the attached drawings, in which

Figure 1 is a sectional schematic side view of a casting receptable of the invention,

Figure 2 is a partly sectional schematic side view of a second embodiment of a casting receptable of the invention,

Figure 3 is a schematic representation of a casting receptable of the invention during the different stages of the casting process,

Figure 4 is a schematic representation of applying the invention to a casting machine, and

Figures 5 to 7 are schematic representations of some shapes of the bottom end of a shutter plug.

[0014] For the sake of clarity, the invention is shown simplified in the figures. The same reference numerals are used for similar parts.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The casting receptable 1 shown in Figure 1 comprises a cylindrical shell 2 having preferably a substantially round cross-profile, but other suitable cross-profile shapes, such as an ellipse and quadrangle, are also possible. The top end of the casting receptable 1 is closed with a lid 3 or the like, making the casting receptable substantially gas tight. In a closed casting receptable, melt cannot get into contact with the surrounding air during transport. In addition, the melt cools clearly less during transport than in open casting receptables. The bottom part of the shell of the casting receptable 1 is shaped like a cut cone 2a. At the bottom of the casting receptable 1, there is a filling opening 4, through which melt metal 5 is fed inside the casting receptable and correspondingly out of it. An elongated shutter plug 6 is arranged through the casting receptable 1 and has a bottom end in the shape of a sharp cone. The

shutter plug 6 opens and closes the filling opening 4 when moved vertically Y by means of an actuator 7. The actuator 7 is preferably a pressure medium cylinder, but any other power unit and mechanism can also be used to provide the required linear movement. The return movement of the shutter plug can be arranged by means of a spring 8. In the solution of Figure 1, the shutter plug 6 is shown in its closed position. Correspondingly, the open position of the shutter plug 6 is shown in Figure 1 with a dashed line. The vertical cross-profile of the lowest section of the shutter plug 6 is substantially in the shape of a quadrangle standing on its tip, whereby it comprises sealing surfaces 6a and 6b that in the closed position are arranged to press tightly against the sides of the filling opening 4. The spring 8 then presses the shutter plug 6 against the bottom end of the shell 2, whereby a compression stress acts on the shell due to the springback force, which preferably reduces the creeping tendency of metal casting receptables and further improves the strength of fragile ceramic casting receptables. The outer surfaces 6c and 6d of the bottom end of the shutter plug 6 form a sharp point at the bottom end of the casting receptable. The angle of inclination of the outer surfaces 6c and 6d is preferably the same as that of the conical bottom end 2a of the shell 2, whereby the bottom end of the casting receptable 1 becomes streamlined. The angle of the bottom end of the shutter plug 6 can differ to some extent from the angle of the bottom end 2a of the shell 2, and still they form a substantially uniform conical and streamlined outer surface at the bottom of the casting receptable.

[0016] After the casting receptable 1 is immersed to a predetermined depth of the melt 5 in the furnace, the shutter plug 6 is opened by pushing it downwards by means of the actuator 7 to allow the melt metal 5 to flow inside the casting receptable 1 through the gap between the sides of the filling opening 4 and the sealing surfaces 6a, 6b of the shutter plug 6. Because the bottom end of the shutter plug 6 is sharp, and further because the bottom part of the casting receptable is conical, protective slag 9 on the surface of the melt 5 and impurities risen to the surface of the melt 5 are moved smoothly aside when the casting receptable 1 is immersed with its sharp point first into the melt 5 in the melting furnace. Because the shutter plug 6 forms a substantially uniform outer surface with the shell 2, no impurities remain at the bottom of the casting receptable that could enter the casting receptable when the filling opening 4 opens.

[0017] On the outer surface side of the casting receptable 1, there is

a first sensor 10 that indicates the immersion depth of the casting receptable 1 into the melt 5. Further, inside the casting receptable 1, there is a second sensor 11 that indicates the level of the melt 5a inside the casting receptable, i.e. the degree of fullness of the casting receptable 1. The sensors 10 and 11 are connected to a control unit 12 that controls the functions of the casting receptable, such as the immersion of the casting receptable into the melt, the transfer of the casting receptable from the melting furnace to the casting site, and the opening and closing of the shutter plug.

[0018] Figure 1 further shows a channel 13 for feeding shielding gas into the casting receptable 1. A suitable inert gas, such as nitrogen, that does not react harmfully with the melt metal can be used as the shielding gas. By feeding shielding gas at high pressure from the channel 13 above the melt 5a in the casting receptable 1, it is possible to speed up the emptying of the melt from the casting receptable, if necessary.

[0019] The casting receptable shown in Figure 2 differs from the construction shown in Figure 1 in its shutter plug 6, for instance. In this solution, the shutter plug 6 is arranged to open towards the inside of the casting receptable, i.e. contrary to Figure 1. In the low position, the sealing surface 6a of the shutter plug 6, which is round in cross-profile, is tightly against the inside edges of the filling opening 4. The lowest part of the shutter plug 6 is shaped like a sharp point 6d in such a manner that when closed, the shutter plug 6 forms together with the convergent bottom part 2a of the shell 2 a casting receptable 1 that is sharp-pointed at the bottom. In the solution of the figure, the height of the second sensor 11 monitoring the level of the melt 5a inside the casting receptable 1 can be adjusted. At its simplest, the arm 11a of the second sensor 11 is equipped with threads and the lid 3 correspondingly has a threaded counter part, whereby the elevation of the sensor can be steplessly adjusted by turning the sensor 11 around its longitudinal axis. Alternatively, the lid 3 has suitable quick-release elements for locking the sensor to the desired elevation. At their simplest, both the first sensor 1 and the second sensor 11 are rods that are made of an electrically conductive and heat-resistant material, such as steel. The sensors 10 and 11 are electrodes of a kind, to which electric current is led. The casting receptable 1 can also be made of an electrically conductive material, in which case the casting receptable is arranged to serve as a second electrode. When the level of the melt 5 or 5a reaches the outermost end of the sensor 10 or 11, the metal melt acts as an electrically

conductive medium between the sensor and the casting receptable. The creation of an electric circuit between the bottom end of the sensor 10 and the casting receptable 1 indicates that the casting receptable 1 is immersed in the correct depth in the melt 5. Correspondingly, the creation of an electric circuit between the bottom end of the sensor 11 and the casting receptable 1 indicates that a sufficient amount of melt 5a is in the casting receptable 1. If the casting receptable 1 is made of a non-conductive material, the sensor can comprise two electrodes at a distance from each other.

[0020] Figure 3 shows a transport apparatus 14 for transferring the casting receptable 1 from the melting furnace 15 to the casting site 16. The transport apparatus 14 comprises a handling arm 17 to which the casting receptable 1 is fastened. By means of the handling arm 17, the casting receptable 1 can be moved vertically A for instance when the casting receptable is immersed into the melt 5. The handling arm 17 can preferably be extended and retracted telescopically. The handling arm 17 is suspended by means of reels 21 or the like from a guide bar 18, along which it can be moved horizontally B from the melting furnace 15 to the casting site 16. The control unit 12 is arranged to also control the operation of the transport apparatus 14. At the casting site 16, the handling arm 17 lowers the casting receptable 1 (shown as a dashed line) to the feed channel 20 of the casting mould 19. The conical bottom end of the casting receptable 1 seals against the sides of the feed channel 20 preventing the surrounding air from entering the casting mould 19 from the feed channel 20.

[0021] In Figure 4, the casting receptable 1 has been brought by means of the handling arm 17 to the feed channel 20 of a casting machine 22. The feed channel 20 comprises a sealing 23, against which the conical shell 2a of the casting receptable presses in a gas-tight manner. Alternatively, it is possible to feed pressurized shielding gas, such as nitrogen, from a channel 25 to a collar 24 arranged around the joining point between the casting receptable 1 and the feed channel 20 to prevent the surrounding air from entering into the feed channel 20. When the casting receptable 1 is at the feed channel 20 in such a manner that the entry of outside air to the feed channel is prevented, shielding gas is fed from a channel 26 to a feed cylinder 27 of the casting machine 22. The shielding gas flushes out the gases in the casting machine 22 and mould 19. Alternatively, the mould 19 is connected to a vacuum pump 28 that creates a negative pressure in the mould 19 and casting ma-

chine 22. This ensures that the metal melt does not come into contact with undesirable gases during casting. The casting is done in such a manner that the shutter plug 6 opens the filling opening 4 of the casting receptable 1 to allow the melt 5a to enter the feed channel 20 of the casting machine 22 and the feed cylinder 27. When a sufficient amount of melt is in the feed cylinder 27, a feed piston 29 strikes and pushes melt into the mould cavity 19a of the mould 19. After this, the feed piston 29 makes a return movement, the mould 19 is opened and the formed piece is removed, and a new gas flushing or negative pressure creation is performed before the next stroke of the feed piston 29.

[0022] Figure 5 shows a shutter plug 6 with a paraboloid bottom end. In this case, too, the shutter plug is at its bottom end sharp enough to push protective slag and impurities to the sides of the casting receptable as described above. The bottom end of the shutter plug 6 shown in Figure 6 is in the shape of a pyramid. Further, in the special case shown in Figure 7, the bottom end of the shutter plug 6 is in the shape of a hemisphere. This latter shape is also capable of pushing smoothly through the protective slag. The bottom part 2a of the casting receptable is preferably shaped to substantially correspond to the shape of the bottom end of the shutter plug 6.

[0023] The drawings and the related description are only intended to illustrate the idea of the invention. The invention may vary in detail within the scope of the claims.